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Special edition

A methodology for urban and regional planning: application in Cachoeira do Sul, Brazil

Uma metodologia para o planejamento urbano e regional: aplicação em Cachoeira do Sul (RS, Brasil)

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ABSTRACT

We aim to demonstrate the methodology used in the critical analysis of the municipality of Cachoeira do Sul (state of Rio Grande do Sul, Brazil), which had its Master Plan recently revised and approved, verifying the urban practices implemented until then in the city. For the application of the methodology, data surveys, studies and mappings were carried out with systematization of a geographic database in a GIS environment, as well as on-site technical visits and application of questionnaires to apprehend the opinion of the population on important subjects in the development of the municipality, consolidating the technical and community readings of the territory. From these data, always guided by group discussions, we developed diagnosis, prognosis, scenarios, and guidelines, macrozoning and intervention proposals, filling gaps in the Master Plan in relation to planning with the landscape, the open space system and the development of the city and the region. Among the developed proposals, those related to urban mobility were highlighted in this article - urban and rural cycle lanes.

Keywords: Urban planning; Regional planning; Geotechnologies; Municipal development; Bike lane

RESUMO

Este trabalho tem como objetivo demonstrar a metodologia utilizada na análise crítica do município de Cachoeira do Sul (RS), que teve seu Plano Diretor recentemente revisado e aprovado, constatando as práticas urbanísticas até então implementadas na cidade. Para a aplicação da metodologia, foram realizados levantamentos de dados, estudos e mapeamentos com sistematização de um banco de dados geográfico em ambiente de SIG, assim como visitas técnicas in loco e aplicação de questionários para apreensão da opinião da população sobre assuntos importantes no desenvolvimento do município, consolidando as leituras técnica e comunitária do território. A partir desses dados, sempre pautados por discussões em grupo, foram elaborados diagnóstico, prognóstico, cenários e diretrizes,

macrozoneamento e propostas de intervenção, preenchendo lacunas no Plano Diretor com relação ao planejamento com a paisagem, o sistema de espaços livres e o desenvolvimento da cidade e da região. Dentre as propostas desenvolvidas foram destacadas neste artigo aquelas relacionadas à mobilidade urbana — ciclofaixas urbanas e rurais.

Palavras-chave: Planejamento urbano; Planejamento regional; Desenvolvimento municipal; Geotecnologias; Ciclofaixa

1 INTRODUCTION

This paper refers to research developed in the Urban and Regional Planning course, as part of Architecture and Urbanism degree, at the Federal University of Santa Maria, Cachoeira do Sul Campus (state of Rio Grande do Sul, Brazil), under the guidance of professors Bárbara Giaccom, Débora Gregoletto and Débora Schöffel. The objective was to analyze, diagnose and establish guidelines, in terms of urban and regional planning, for Cachoeira do Sul, a medium-size municipality (i.e., 81,552 inhabitants – IBGE, 2023) in the center of the southernmost state of Brazil (Rio Grande do Sul).

It is expected that undergraduate students in Architecture and Urbanism degree acquire, throughout their training, the conceptual, technical, and practical foundation suitable to qualify them to work in the most diverse areas that the profession allows. Considering the importance of urban insertion even in the smallest of projects, knowing how to work *the* city and *with the* city is an essential skill for future architects and urban planners.

The research here presented sought to address the complexity of the problems found in Cachoeira do Sul, which ought to be solved or, at least, minimized, and to help public authorities and private agents with tools to guide municipality growth and development, aiming at social justice and environmental balance.

2 MOTIVATION

One must note that much of what the city of Cachoeira do Sul has experienced, in terms of urban planning, stems from the 1980s; thereon urban issues would only be discussed again with the revision of the Urban Development Master Plan (UDMP) of Cachoeira do Sul, instituted by Municipal Law nº 1.983, of November 4, 1983. The revision of the UDMP had the participation of students and professors from the Federal University of Santa Maria (UFSM), Cachoeira do Sul Campus, between 2019 and 2021, and was recently approved (December 2021). That is, all the legal procedures in terms of legislation and management instruments that guided urban development, regulations, the use of resources, etc., until recently, essentially came from a way of thinking about the city prior to the City Statute (in Portuguese, *Estatuto da Cidade* - Federal Law 10.257/2001 - Brasil, 2001). In addition, it is emphasized that, since 1983, the methodology employed has evolved significantly, popular participation has gained emphasis and, above all, it has been realized that the city model needs to be rethought every five years.

It is also important to consider that, in these 30 years of the UDMP previously valid, Cachoeira do Sul has undergone significant changes and increments in its productive matrix, civil and infrastructure construction, growth expressed as urban fabric expansion, etc. In the 2000s, a spatial rearrangement of productive activities is observed, in which grain storage and processing structures suffer abandonment or obsolescence, other structures occupy areas that were formerly economically important, including next to the port of Jacuí River; the metalworking industry expands its manufacturing units, there is the implementation of the Emergency Care Unit - ECU (in Portuguese, *Unidade de Pronto Atendimento - UPA*) (2017) and a unit of the Social Service of Transport (in Portuguese, *Serviço Social do Transporte - SEST*) and National Service of Transport Learning (in Portuguese, *Serviço Nacional de Aprendizagem do Transporte - SENAT*) (2022), in addition to an off-campus campus Federal University

of Santa Maria (in Portuguese, *Universidade Federal de Santa Maria - UFSM*) (2014) in a rural area of the municipality.

Cachoeira do Sul is part of a group of municipalities in Rio Grande do Sul that maintain the population shrinking trend seen in recent decades; factors contributing to this statistics involve the national trend of falling fertility (i.e., families, in general, are having fewer children) and the substantial loss of young people after school age (i.e., young adults migrate in search of higher education or better employment and income conditions). It is believed that the arrival of new enterprises and educational institutions in the municipality will ensure a resumption of population and economic growth. There remains great expectation regarding the updating of demographic statistics that will be made possible with the publication of the 2022 Demographic Census being carried out by Brazilian Institute of Geography and Statistics (in Portuguese, *Instituto Brasileiro de Geografia e Estatística - IBGE*), which will certainly contribute to the research and analysis of this urban and regional system. The use of up-to-date and detailed information about the urban environment and its population is strategic for urban and regional planning and management (Giaccom-Ribeiro, 2019).

The framework presented appears to be substantial to justify research that seeks to contribute to the analysis of the spatial and socioeconomic structure of Cachoeira do Sul and its regional insertion, aiming at the continuous planning process. The structuring of a geospatial database enables analyzing diverse data in an integrated manner, resulting in gains in information extraction to support planning, as well as in decision-making on municipal management issues.

3 MATERIAL AND METHODS

A first approach to the object under study used already established databases, such as demographic and socioeconomic data from IBGE (Brazilian Institute of Geography and Statistics), environmental data from State of Rio Grande do Sul Foundation for Environmental Protection (in Portuguese, *Fundação Estadual de*

Proteção Ambiental - FEPAM), MapBiomas (Annual Mapping Project of Land Use and Coverage in Brazil), database of the Municipality of Cachoeira do Sul, among others, considering geographic, physical-territorial, economic, social, political, morphological, administrative aspects and infrastructure conditions. Data and impressions were also acquired *in loco*, in field work that sought to learn about the natural and built environment, social experiences and the population (i.e., through interviews and questionnaires).

The activities were developed in a studio dynamic (i.e., *atelier*), mainly through instances of collective group discussion. In the elaboration of the work, the students visited the study area, surveyed data, collected in situ data, including conversations and interviews with space-producing agents and stakeholders, face-to-face and virtual questionnaires to apprehend the population's opinion on important issues concerning the municipality development. A geographic database was built and systematized, enabling data analysis that led to the construction of the diagnosis, thus consolidating the technical and community readings of the territory; to the elaboration of prognosis, scenarios, and guidelines; macrozoning structuring; and formulation of intervention proposals.

In this work, there was a relevant use of geotechnologies, that is, instruments that enable obtaining, analysis, processing, and availability of geographic information, so that all information that has a known geographic position can be used and/or analyzed from geotechnologies (Andrades Filho, 2021). Through geoprocessing, a branch of activities that comprises theoretical and computational techniques and methods and that uses computational representations of geographic space to model and analyze spatio-temporal phenomena, employing computational tools (i.e., such as Geographic Information Systems - GIS) to perform complex analyses, to integrate data from different sources, and to create georeferenced databases, several maps were produced to support the construction of a solid diagnosis.

The systematization of a geographic database in a GIS environment enabled data overlapping and crossing, integrating them into maps for analyzing various aspects and constraints: geographic, physical-territorial, environmental, social, economic, political-administrative, legal, morphological, infrastructural, etc., that is, all the intervening aspects in the planning of the urban and regional space, considering the given study area. Some of the mapped themes involved analyzes of the natural environment, relief, altimetry and slope, agricultural land uses, plant formations, watersheds, water resources, conservation units and permanent preservation areas (PPA), regional insertion, urban network, regions under influence of Cachoeira do Sul, districts articulation, urban occupation and evolution and historical interest sites, municipal and regional road system (including rail and road modes), connection between rural and urban zones, transport system and infrastructure of different modes (i.e., bicycles, automobiles, public transport, freight transport), availability of public transport service, urban road paving and state of conservation, road signs, traffic-generating and traffic-attracting poles, places with high occurrence of accidents involving pedestrians, urban land use and occupation, demography over time, considering gender and age groups, residents income, poverty clusters, characterization of the city's neighborhoods, distribution of administrative, health and education equipment, basic sanitation system and infrastructure (including sewage system, water supply, solid waste collection and urban drainage), flooding-sensitive areas, ecosystem services, irregular occupations, and housing programs.

Technical visits to the study area enabled observing peculiarities of the neighborhoods, streets, and public buildings; also provided opportunity of direct contact and interaction with local population. In addition, an online questionnaire was carried out so that there could be greater popular participation, with the intention of perceiving their interests and criticisms in relation to the city, thus enabling a better community reading of the territory.

For a better systematization of the diagnosis, a CSD matrix was produced,

that is, with the constraints, strengths, and deficiencies, which clarified the paths for elaborating the prognosis.

The prognosis allowed the students to clearer perceive the paths that the study area would take in the future – considering short, medium and long terms. Such expectations motivated the conception of scenarios: the "chaotic" (without the implementation of any intervention aimed at improving the negative aspects previously identified), the "viable" and the "utopian" (with all interventions designed to improve the diagnosed situations, without limiting financial, technological, human resources, etc.).

Adopting the "viable scenario", intervention guidelines were established towards the desired results. The guidelines have a strong geographic relationship, so a macrozoning was developed in order to better spatially-structure them. Based on these products, 22 specific proposals were designed in detail addressing problems considered important in the municipality of Cachoeira do Sul and its region; two of which are presented in this paper.

4 RESULTS AND DISCUSSION

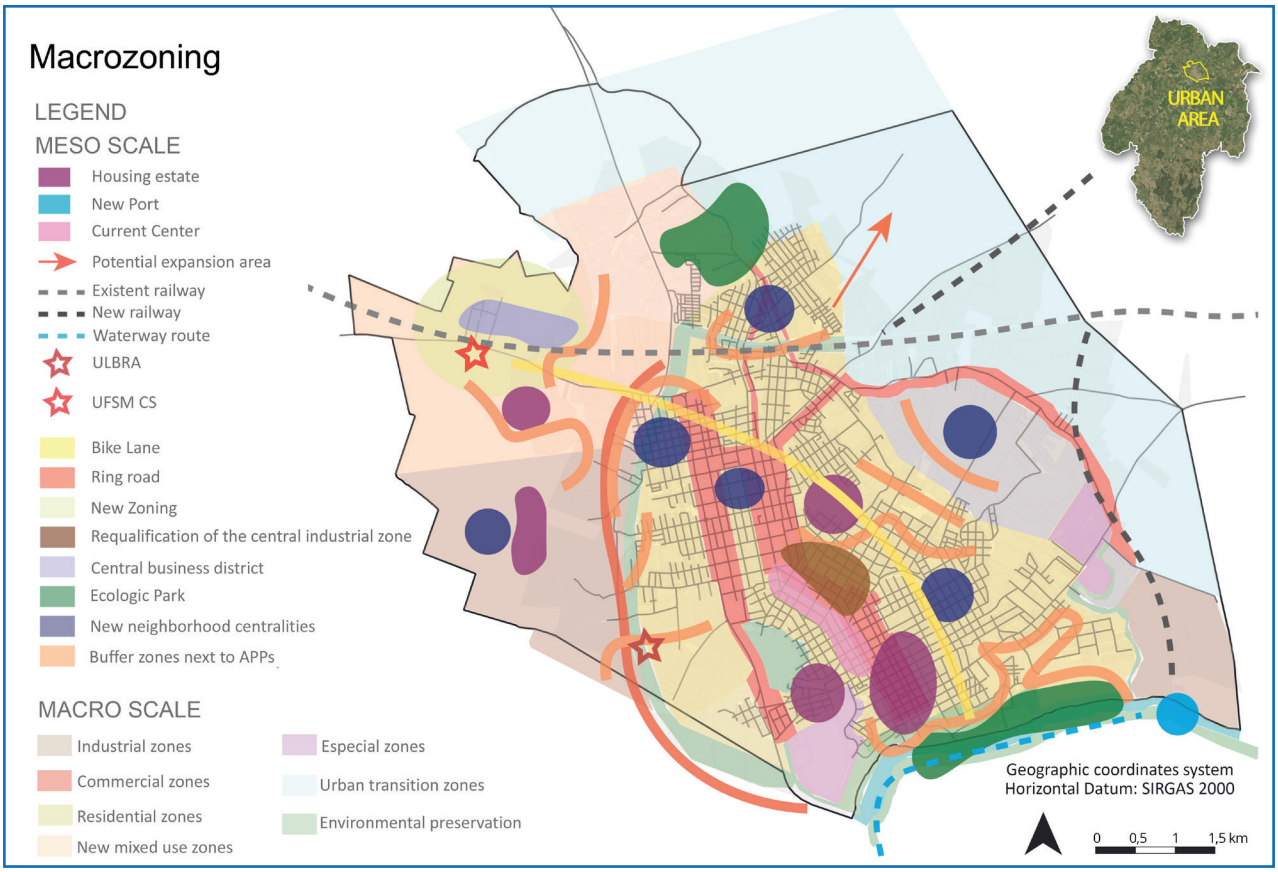
The elaborated macrozoning (Figure 1) indicates the main guidelines developed from the diagnosis, and identifies potential areas and constraints.

Analyzed data enable observing the growing deforestation and degradation of the riparian forest along Jacuí River, either by agricultural use, in the rural area, or by irregular occupations in areas of environmental preservation, in the urban area. The consequences include climate changes, water regime alteration, pollution, erosion of banks, landslides, material damage and economic losses, health risks to the local population, among others.

Urban area grows towards the north, due to the physical barrier to urban expansion imposed by the Jacuí River. Growth is observed without planning and concatenation of actions, lacking infrastructure, subjecting residents of peripheral

areas to situations of social and environmental vulnerability. There is a linear centrality in the south-north axis that concentrates trades and services, and results in greater population density, given the population's interest in residing close to services' supply and to areas of greater economic activity. Around this axis, there are public open areas equipped with more infrastructure and in a better conservation-state, compared to those farther from this centrality axis.

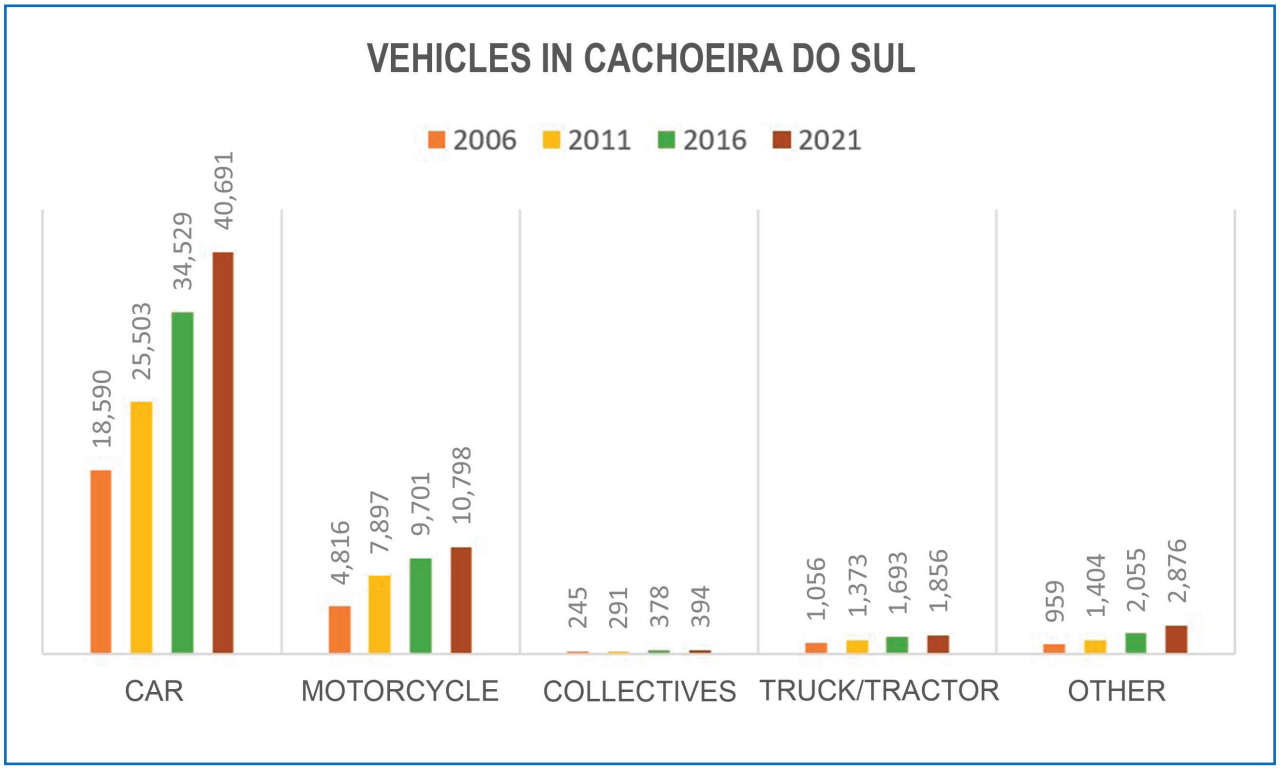
Figure 1 – Collectively proposed macrozoning



Source: Elaborated by the authors (2023)

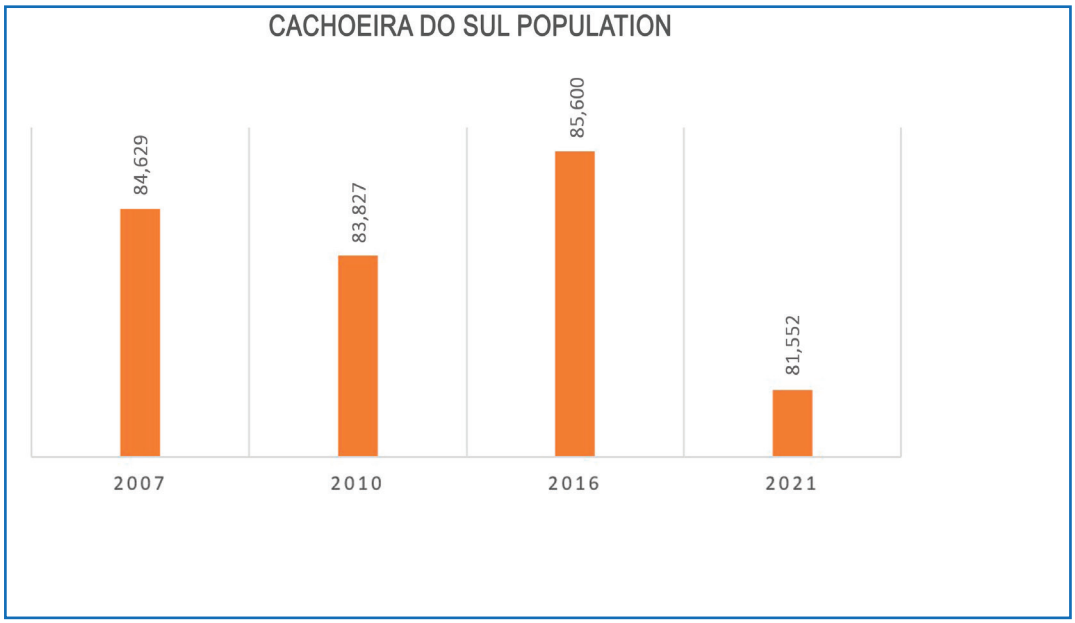
The urban configuration of Cachoeira do Sul, associated with the precariousness of the road system and the public transport service, results in a greater use of individual modes of transport. From 2006 to 2021, the number of vehicles grew significantly, going from 3.61 inhabitants per individual vehicle, in 2006, to 1.58, in 2021, while the population amount decreased (IBGE, 2022) (Figures 2 and 3).

Figure 2 – Number of vehicles in Cachoeira do Sul – 2006 to 2021



Data source: National Traffic Department (2007, 2010, 2016, 2021 apud IBGE, 2022)
Source: Organized by Bruna Kiefer (2022)

Figure 3 – Population in Cachoeira do Sul – 2007 to 2021



Data source: Brazilian Institute of Geography and Statistics (IBGE, 2007, 2010, 2016, 2021)
Source: Organized by Bruna Kiefer (2022)

These values aver what every-day observed: the number of motor vehicles is increasing, resulting in congestion and rush-hour traffic jams (not seen in the past decade), increasing rate of traffic accidents, and environmental, sound, and visual pollution. Among the factors that can explain this phenomenon, such as the precariousness of the public transport service offered in the municipality, the growth of app transport service, and the generalized lack of proper infrastructure for the comfortable and safe circulation of pedestrians and cyclists throughout the city, thus they use the roads in a completely exposed and unsafe manner (Figure 4). Although (shallowly) foreseen in the Mobility Plan and in the Urban Development Master Plan – UDMP (Prefeitura municipal de Cachoeira do Sul, 2019; 2021), currently, Cachoeira do Sul does not have cycle lanes or cycle paths, an infrastructure that would bring many benefits both to the municipality and to its users.

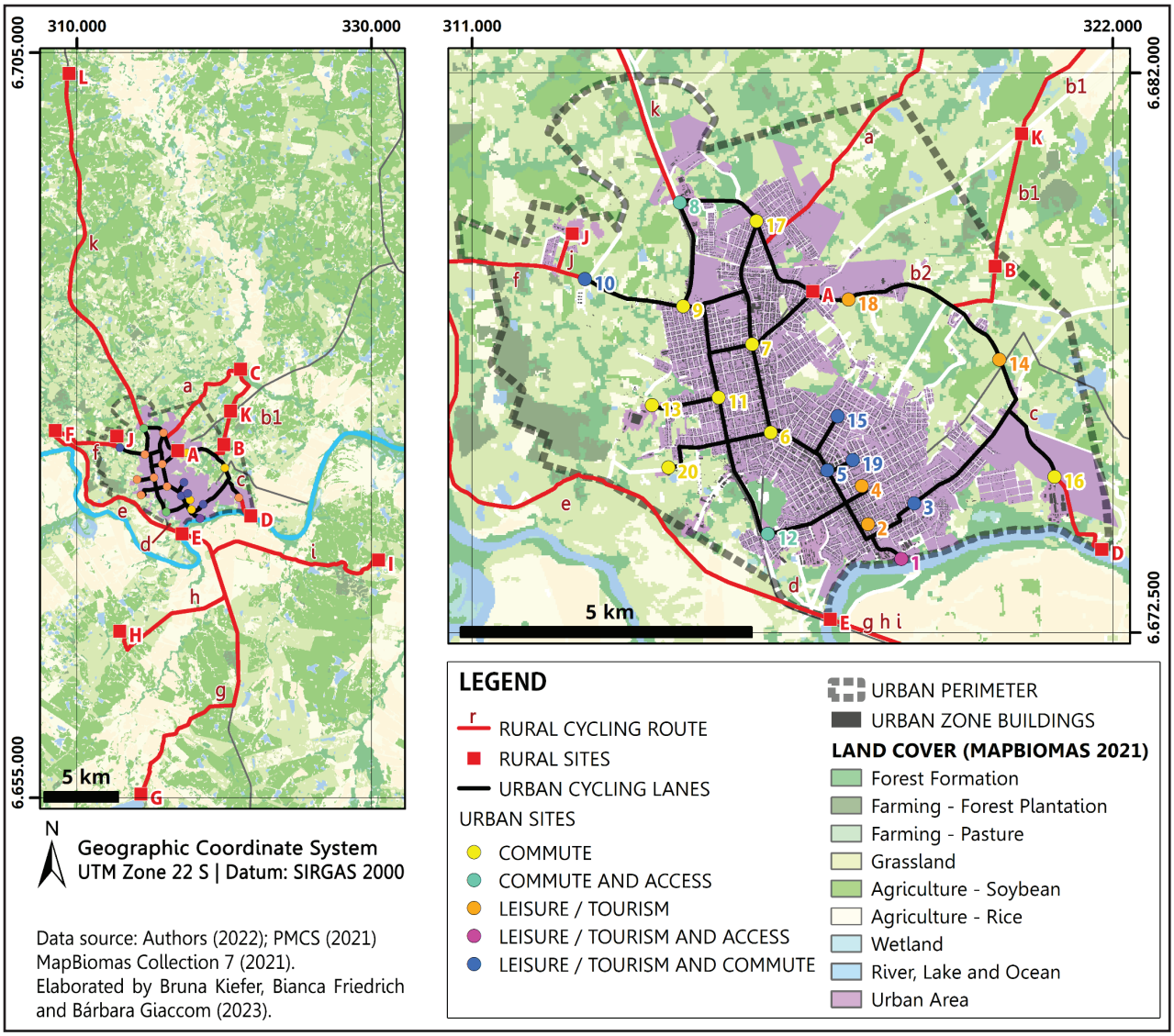
Figure 4 – Cyclists in Cachoeira do Sul using the road even in the absence of appropriate infrastructure

Source: Bruna Kiefer - personal collection (2022)

Thus, the implementation of cycle lanes would bring numerous benefits, being a starting point for Cachoeira do Sul to towards having a more sustainable action, reducing polluting gases emission, offering an alternative mode of transportation, assuring more safety for those who already ride bicycles and, certainly, it would encourage the population to start Active Mobility.

In Figure 5, the urban cycle lane and the rural routes are presented. Each of these proposals are depicted in the following sections.

Figure 5 – Integration of urban and rural bicycle routes proposed for the municipality of Cachoeira do Sul



Source: Organized by Bruna Kiefer, Bianca Friedrich and Bárbara Giaccom (2023)

4.1 Intervention proposal: urban cycle lane

The bicycle lane proposed in the urban area (Figure 5) is intended to assure safety to the population that already uses bicycles as their main daily transport, as well as for cyclists who use them for sports and tourism, in addition to being an incentive for more people to use this mode of transport.

The proposed cycle lane network, just over 38-km-long, to be implemented on

selected arterial and collector roads, has a layout that seeks to contemplate the traffic related to large flows for work and study, in addition to paths normally used for sports and leisure. Chart 1 relates the 20 main sites connected by the urban cycle lanes.

Chart 1 – Sites connected by the urban cycle lanes classified by displacement category

Code	Urban sites	Displacement Category
1	Jacuí River (ferryboat docking)	Leisure / tourism and access
2	Chateau D'eau	Leisure / tourism
3	Fenarroz Exposition Park	Leisure / tourism and commute
4	Municipal Zoo	Leisure / tourism
5	Honorato Square	Leisure / tourism and commute
6	"5 Corners" Roundabout	Commute
7	União Hotel	Commute
8	Horbach (Industry)	Commute and access
9	"Comercial" Roundabout	Commute
10	UFSM University Campus	Leisure / tourism and commute
11	Marcelo Gama Av. Roundabout	Commute
12	City Entrance	Commute and access
13	Screw (Industry)	Commute
14	Pilgrimage Park	Leisure / tourism
15	Soares Square	Leisure / tourism and commute
16	Granol (Industry)	Commute
17	Quinta da Boa Vista Neighborhood	Commute
18	Volta da Charqueada Road	Leisure / tourism
19	Rio Branco Social Club	Leisure / tourism and commute
20	ULBRA University Campus	Commute

Source: Organized by the authors (2023)

The bike lane starts at Moron Street (Figure 5, #**1**) (near the Jacuí River, by the area of the ferryboat docking), passing by some touristic attractions, such as Chateau D'Eau (#**2**) (an important historic interest site), and the Municipal Zoo (#**4**). Maintaining the central connection, it goes through by Honorato Square (#**5**), "5 corners" roundabout (#**6**), and União Hotel (#**7**). It is designed to also link the universities – UFSM (#**10**) and ULBRA (Lutheran University of Brazil) (#**20**), important industries – Screw (#**13**), Granol (#**16**), and Horbach (#**8**), and other important sites in the fringes of urban area, such as Fenarroz Exposition Park (#**3**) and Volta da Charqueada Road (#**14**, #**18**).

Implementing of cycle lanes implies changing the road profile (Figure 6a), in order to allocate adequate space to the modal, with appropriate vertical and horizontal signaling, guaranteeing safety for the cyclist's movement.

Figure 6 – (a) UFSM University Campus (#**10**) seen from the road, including the bicycle lane project; and (b) proposed rural cycle route – Olivas do Sul Farm (site #**B**)

Source: Elaborated by (a) Bruna Kiefer (2022); (b) Bianca Friedrich (2022)

The set of measures designed for Cachoeira do Sul regional planning, in addition to urban cycle lanes, includes rural routes, which are proposed linking the urban cycle lanes to points of interest in the rural area, both for leisure, sports, and touristic purposes, integrating the cycling mode as part of regional planning (Figure 5).

4.2 Intervention proposal: rural cycle route

The growing practice of adventure cycling amidst nature motivated the proposal of a rural cycle route for the municipality of Cachoeira do Sul, which has several rural touristic interest sites, which potentially can be further explored. Aiming to stimulate the local economy through rural tourism, in addition to the already consolidated agricultural sector, areas were identified as potential rural centralities, prospective to attract services, complementary trade and leisure spaces.

Interviews with a group of rural cycling practitioners helped selecting eleven sites of interest for cyclists. The proposed routes have different difficulty degrees, with

options for beginners, intermediates, and those able to more difficulties. The routes were characterized by their distances, topographical profile[1], and the estimated time course. Rural sites and routes are described in Chart 2 and their codes are referenced in Figure 5.

Chart 2 – Description of the rural sites connected by the rural cycle routes

(Continue)

Code Rural sites	Displacement Category
A KM 0	Usually "kilometer 0" is the starting point of the local cyclists' routes. This first point is located at the ERS-403 state road that connects the cities of Cachoeira do Sul and Rio Pardo, and the site is considered an urban/rural limit. The route "**a**" starts at KM 0 (#**A**) and goes to *Ponte de Pedra* (#**C**) (an important historic interest site in Cachoeira do Sul rural area), passing through Imigrantes Avenue, which is paved, enters the *Quinta da Boa Vista* neighborhood (#**17**), and follows a dirt road (i.e., unpaved road) to *Ponte de Pedra*. Route **a** - estimated time course: 42 minutes; difficulty level: beginner. Length: 8.9 km; average slope: 0.95%; steepest slope: 22.4%; maximum elevation: 86.4 m.
B Olivas do Sul Farm	This agribusiness site houses an olive orchard and olive oil industry, also sell seedlings, and teach their knowledge about seedling planting. It is located close to the urban area, being a place with great tourist potential due to its olive orchards and local production. Route "**b1**" goes to Olivas do Sul (#**B**) departing from *Ponte de Pedra* (#**C**). Also, from the Volta da Charqueada Road (#**18**), which is completely paved, you can access the dirt road to Olivas do Sul (route "**b2**") (Figure 6b). Route **b1** - estimated time course: 15 minutes; difficulty level: beginner. Length: 6 km; average slope: 1.04%; steepest slope: 11.9%; maximum elevation: 60.5 m. Route **b2** - estimated time course: 5 minutes; difficulty level: beginner. Length: 1.2 km; average slope: 1.76%; steepest slope: 9.3%; maximum elevation: 22.4 m.
C Ponte de Pedra	This listed cultural heritage stone bridge, from 1848, is one of the first in Brazil, through which Butucaraí River passes. It is located on a private property but has free access. In the surroundings there are private properties, without infrastructure such as commerce, services, etc. Route "**b1**" takes the cyclist from Olivas do Sul (#**B**) to *Ponte de Pedra* (#**C**). It begins on the Volta da Charqueada Road (#**18**) (paved road), accesses the dirt road that first passes through Olivas do Sul, continues to the ERS-403 state road (paved) and gets into private properties of crops and farms, along the Botucaraí River, until it reaches the *Ponte de Pedra*. Route **b1** - estimated time course: 15 minutes; difficulty level: beginner. Length: 6 km; average slope: 1.04%; steepest slope: 11.9%; maximum elevation: 60.5 m.

Source: Organized by the authors (2023)

[1] Elevation and slopes were calculated based on a Copernicus DEM, a Digital Surface Model (DSM) which data were acquired through the TanDEM-X mission between 2011 and 2015. Product used: GLO-30, global coverage at a resolution of 30 meters. Copernicus DEM can be openly accessed through: https://spacedata.copernicus.eu/

Chart 2 – Description of the rural sites connected by the rural cycle routes

(Continue)

Code Rural sites	Displacement Category
D Old Port	Located on the banks of the Jacuí River, the port is considered of great economic value for Cachoeira do Sul. It is currently abandoned, but the Municipality intends to reactivate it. Its region is occupied by Granol (#**16**), an important industry that crushes and processes oilseeds, adding value to by-products, derivatives, and biofuels. It is easily accessible, located close to the urban area. This site does not have infrastructure for the cyclists, such as commerce, services, or toilets. Route "**c**" starts at Orlando da Cunha Carlos Street, connected to the urban cycle lane, it follows the road towards Granol (#**16**) and continues along the dirt road until the access gate to the large port area of Cachoeira do Sul (#**D**). Route **c** - estimated time course: 11 minutes; difficulty level: beginner. Length: 3.1 km; average slope: 1.53%; steepest slope: 30.54%; maximum elevation: 48 m.
E Fan-dango's Bridge	Route "**d**" connects at the city entrance (#**12**), partially using the urban cycle lane, to *Ponte do Fandango*, a bridge that crosses the Jacuí River. It is a quick route that also offers the possibility of continuing to other rural route points, such as to the Railway Station (#**F**) by an alternative route that passes through private properties of crops and farms along the Jacuí River – route "**e**". Route **d** - estimated time course: 8 minutes; difficulty level: beginner. Length: 1.9 km; average slope: 1.97%; steepest slope: 16.2%; maximum elevation: 41 m. Route **e** - estimated time course: 60 minutes; difficulty level: advanced. Length: 13.5 km; average slope: 0.2%; steepest slope: 29.1 %; maximum elevation: 27.3 m.
F Railway Station	Former "Ferreira Railway Station", this site is part of the cultural heritage of Cachoeira do Sul, due to its great historical relevance for the city. Nowadays, it is in partially in ruins and abandoned, even though, still attracts the curious visitors' sight, having great touristic potential. This is an interesting site for urban intervention due to its proximity to an urban expansion zone, despite its location in the rural zone. Route "**f**" to the Ferreira Railway Station (#**F**) starts at UFSM University Campus (#**10**), connecting through the urban cycle lane (paved road). Route **f** - estimated time course: 12 minutes; difficulty level: beginner. Length: 4.7 km; average slope: 0.94%; steepest slope: 14.9%; maximum elevation: 44.8 m.
G Capané Dam	It is a location of scenic beauty, used for leisure, without infrastructure, commercial or services establishments, or toilets. It is surrounded by private properties. Route "**g**" is the longest one, a continuation of route **d**, to *Ponte do Fandango* (#**E**), through the federal highway BR-153 (fully paved); in the locally of *Pedras*, the route continues through Capané Dam Road, a dirt road, for 12 km until the dam (#**G**). Route **g** - estimated time course: 69 minutes; difficulty level: advanced. Length: 23 km; average slope: 0.33%; steepest slope: 22.3 %; maximum elevation: 76 m.

Source: Organized by the authors (2023)

Chart 2 – Description of the rural sites connected by the rural cycle routes

(Conclusion)

Code Rural sites	Displacement Category
H Irapuá Farm - Willy Haas	This farm does not offer any kind of infrastructure to the cyclists, but it is a reference point due to its of great economic importance for Cachoeira do Sul. Route "**h**" is also a continuation of route **d**, to *Ponte do Fandango* (#**E**): after 5.5 km going through the federal highway BR-153 (fully paved), the route continues through a dirt road, for 14.7 km until the Irapuá Farm (#**H**). Route **h** - estimated time course: 65 minutes; difficulty level: intermediate. Length: 14.8 km; average slope: 0.44%; steepest slope: 21.4%; maximum elevation: 64.9 m.
I Tafona Farm	This is an historic interest site due to the Portuguese colonial farmhouse, preserved for 11 generations, with original furniture, lamps and other preserved objects. It is listed by the Institute of Historical and Artistic Heritage of Rio Grande do Sul (IPHAN-RS) for its economic and historical importance in the occupation of the territory. There is no commercial or services establishments in the surroundings. Visitation is charged per person; the farm offers toilets and drinking fountain for its visitors. Route "**i**" is a continuation of route **d**, to *Ponte do Fandango* (#**E**), through the federal highway BR-153 (fully paved) for 2.8 km; in the locally of *Porteira 7*, the route continues through dirt road for 12.6 km until the Tafona Farm (#**I**). Route **i** - estimated time course: 43 minutes; difficulty level: advanced. Length: 15.4 km; average slope: 0.63%; steepest slope: 21.4%; maximum elevation: 98.2 m.
J Flying Club	This aerodrome (#**J**) has a private pilot and an agricultural pilot training school, a flying club and several aeroagricultural companies, which meet the demand for the application of agricultural defensives in the crops of the region. The access to the site is paved. In the surroundings, there are residences, minimal infrastructure, such as toilets, and eventually there is food trade. Rout "**j**" is a fast one, connected with the urban bike lane that goes to UFSM University Campus (#**10**) and later on to the Flying Club (#**J**), following to Ferreira Railway Station (#**F**). Route **j** - estimated time course: 9 minutes; difficulty level: beginner. Length: 1.23 km; average slope: 1.58%; steepest slope: 18.7%; maximum elevation: 19.5 m.
L Witeck Park	Witeck is the largest private park in area in Latin America, with different types of vegetation, paths/trails for walking, picnics areas, toilets, and water fountain. There are no stores in the park, but there are trade and service. Entrance is charged per person; the journey through the park paths takes about 1 hour-walking. Route "**k**" starts at KM 0 (#**A**), connects with the urban cycle lane on Imigrantes Avenue passing through *Quinta da Boa Vista* neighborhood (#**17**) and Horbach (#**8**), a large industry that produces storage silos, cereal dryers, metallic structures, pavilions, and other metallic equipment. From BR-153 highway access interchange, at Horbach, the route follows through BR-153, on which the park is located (completely paved road). Route **k** - estimated time course: 85 minutes; difficulty level: advanced. Length: 28.9 km; average slope: 0.31%; steepest slope: 28%; maximum elevation: 89.3 m.

Source: Organized by the authors (2023)

5 FINAL CONSIDERATIONS

The work sought to analyze the municipality of Cachoeira do Sul through technical reading, that involved the use of digital tools, and community reading, that covered the perception of residents. A diagnosis was carried out, and guidelines and proposals were established in terms of urban and regional planning. The study sought to understand the complexity of the problems found in the city that were not contemplated in the new Urban Development Master Plan and that need to be solved. 22 specific proposals were elaborated aiming to tackle the problems detected as important for the growth of the municipality and the region, especially related to urban mobility; two proposals are presented in this paper, namely urban and rural cycle lanes.

The steps developed in this work averred that the use of geotechnologies as essential both as a starting point for the identification of the problems that generated important discussions, as for the elaboration of proposals relevant to the territory in which they are inserted and the population they aim to serve. The academic spark resulted in discussions and proposals that fill-in the lack of propositional guidelines in the UDPM regarding planning with the landscape, thinking the city as an integrated system, including the open-spaces system, and the development of the municipality and the region.

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REFERENCES

ANDRADES FILHO, C. O. Geotecnologias. *In*: HERNANDEZ, A. R. C. et al. (org.) **Glossário de verbetes em ambiente e sustentabilidade**. São Francisco de Paula (RS): UERGS, 2021. p. 121-124. ISBN: 9786586105186. Disponível em: http://hdl.handle.net/10183/224169. Acesso em: 11 jun. 2023.

BRASIL. **Estatuto da Cidade. Lei nº 10.257, de 10 de julho de 2001**. Regulamenta os arts. 182 e 183 da Constituição Federal, estabelece diretrizes gerais da política urbana e dá outras providências. Diário Oficial da União: seção 1, Brasília, DF, ano 142, n. 138, 11 jul. 2001. Disponível em: https://www.planalto.gov.br/ccivil_03/leis/leis_2001/l10257.htm. Acesso em: 11 jun. 2023.

BRASIL. **Novo Código Florestal Brasileiro**. **Lei nº 12.651, de 25 de maio de 2012**. Provides for the protection of native vegetation; (...) and takes other measures. Diário Oficial da União: seção 1, Brasília, DF, ano 149, n. 102, de 28/05/2012.

PREFEITURA MUNICIPAL DE CACHOEIRA DO SUL. **Plano de Mobilidade Urbana de Cachoeira do Sul**. Cachoeira do Sul, 2019. Disponível em: https://www.ufsm.br/app/uploads/sites/221/2023/06/PLANMOB-FINAL.pdf. Acesso em: 11 jun. 2023.

PREFEITURA MUNICIPAL DE CACHOEIRA DO SUL. **Plano Diretor de Cachoeira do Sul (PDCS)** - Lei Complementar nº 7, de 29 de dezembro de 2021. Institui o Plano Diretor de Cachoeira do Sul e dá outras providências. Diário Oficial do Município, n. 39, 30 dez. 2021. Disponível em: https://www.cachoeiradosul.rs.gov.br/uploads/diario_2021032917385d3b44f47d06d0bb5ec91f354dc5e0a4.pdf. Acesso em: 11 jun. 2023.

GIACCOM-RIBEIRO, B. M. Sensoriamento remoto para mapeamento urbano: classificação de cobertura, uso e ocupação do solo. *In*: XIX Simpósio Brasileiro de Sensoriamento Remoto - SBSR, 2019, Santos, SP. **Anais**... São José dos Campos, SP: Instituto Nacional de Pesquisas Espaciais - INPE, 2019. v. 19. p. 1811-1814. Disponível em: http://marte2.sid.inpe.br/col/sid.inpe.br/marte2/2019/10.31.12.08/doc/97995.pdf . Acesso em: 11 jun. 2023.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Censo Demográfico 2010**. Características da População e dos Domicílios - Resultados do Universo. Rio de Janeiro: IBGE, 2010. Disponível em: https://www.ibge.gov.br/estatisticas/sociais/trabalho/9662-censo-demografico-2010.html?edicao=10503&t=resultados. Acesso em: 11 jun. 2023.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Censo Demográfico 2022**. Resultados de População. Brasil e Grandes Regiões, Unidades da Federação, Concentrações Urbanas e Municípios. População residente, Área territorial e Densidade demográfica. Rio de Janeiro: IBGE, 2023. Disponível em: https://www.ibge.gov.br/estatisticas/sociais/populacao/22827-censo-demografico-2022.html?edicao=37225&t=resultados. Acesso em: 11 jun. 2023.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Contagem da População 2007**. Resultados da publicação divulgada em 21/12/2007. Rio de Janeiro: IBGE, 2007. Disponível em: https://www.ibge.gov.br/estatisticas/sociais/habitacao/9065-contagem-da-populacao.html?edicao=9679. Acesso em: 11 jun. 2023.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Estimativas da população residente nos municípios e para as unidades da federação brasileiros com data de referência em 1º de julho de 2016**. Rio de Janeiro, RJ: IBGE, 2016. Disponível em: https://www.ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html?edicao=17283&t=downloads. Acesso em: 11 jun. 2023.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Estimativas da população residente nos municípios e para as unidades da federação brasileiros com data de referência em 1º de julho de 2021**. Rio de Janeiro, RJ: IBGE, 2021. Disponível em: https://www.ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html. Acesso em: 11 jun. 2023.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Frota de veículos**. Rio de Janeiro, RJ: IBGE, 2022. Disponível em: https://cidades.ibge.gov.br/brasil/pesquisa/22/28120?ano=2021&localidade1=430300. Acesso em: 11 jun. 2023.

MDR - Ministério do Desenvolvimento Regional; MMA - Ministério do Meio Ambiente; GIZ - Deutsche Gesellschaft für Internationale Zusammenarbeit GMBH. **Guia para Elaboração e Revisão de Planos Diretores**. Versão para teste. Projeto ANDUS Apoio à Agenda Nacional de Desenvolvimento Urbano Sustentável no Brasil. Brasília: MDR, 2019. 918 p.

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